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ELECTRONIC SUBSYSTEM FOR NORMAL INCIDENCE ULTRAVIOLET SPECTROME--ETC(U)
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ELECTRONIC SUBSYSTEM FOR NORMAL INCIDENCE ULTRAVIOLET SPECTROMETER

Robert S. Hills

TRI-CON ASSOCIATES, INC.
765 Concord Avenue
Cambridge, Massachusetts 02138

390416

September 10, 1976

Final Report: Period Covered
1 September 1973 to 30 June 1976

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AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
HANSCOM AFB, MASSACHUSETTS 01731

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Electron Spectrometer
Electronics Subsystem

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the design, fabrication and launch of an electronics subsystem for a normal incidence ultraviolet grating spectrometer for sounding rockets. It also describes an electronics subsystem built for an electron spectrometer which was launched as an auxiliary experiment carried by the grating spectrometer.

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1B

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

This report covers the design, fabrication, and checkout and launch of the electronics subsystem for the RS-61 normal incidence, UV grating spectrometer including the electronics for an auxiliary electron analyzer.

The personnel who worked on this contract were Chester G. Kuczun, Robert S. Hills, Norbert F. Robertie, and Timothy A. Doyle.

The RS-61 spectrometer, exclusive of the electronics, was built by Comstock & Wescott, Inc., Cambridge, Massachusetts under contract F19628-74-C-0002.

An electronics system similar to the system described in this report was built for Spectrometer RM 58II under a subcontract from Comstock & Wescott (Contract F19628-72-C-0254).

2. ELECTRONICS FOR GRATING SPECTROMETER

2.1 General

The function of the electronics for the grating spectrometer is to count pulses from a photomultiplier which produces pulses for photons hitting its cathode, and to control a stepping motor which scans wavelength in the Fastie-Ebert Spectrometer.

The spectrometer steps at the rate of 224 steps per second. Thirteen steps are required to scan one Angstrom. The instrument scans from 1700 Å to 3500 Å. The time for each step is 4.464 milliseconds and is controlled by a crystal clock to 0.01 percent. The photomultiplier output pulses are counted during all except the first 15 microseconds of the step time or 4.449 milliseconds. The initial 15 microseconds is used to transfer the count to a shift register and reset the counters.

The count data and wavelength step identification is connected to a telemetry format consisting of a PCM frame of three 16 bit words. The first word is a sync word, the second word is the wavelength position in Angstroms represented by four binary coded decimal digits and the third word (four digit binary coded decimal) is the totalized count of the photon pulses during 4.449 milliseconds at the wavelength indicated in second word.

A timing diagram showing the PCM format and how it is generated is given in Figure 1.

The 16 bit sync word is used by a computer in the reduction of the flight data. A console built on a previous contract is used to display the output of the instrument during testing, calibration, and pre-launch operation. It is also used to give a quick look at the flight data by producing an

analog output of the photon count rate from real time telemetry or tape playback. This console's decoding electronics is synchronized to the instrument's data train by detecting the high amplitude bits at the start of the sync word.

The stepping motor has four windings which are energized in a specific sense to produce rotation. It rotates 90 degrees per step and thus requires four different logic sequences which are generated and controlled by the electronics system.

In addition to the functions described above, the electronics subsystem includes a pulse amplifier, test pulse generator, high voltage power supply system, a filter actuation/drive circuit which inserts a background filter in the photon beam at 1900 Å and 2400 Å and an attenuator actuation/drive circuit which inserts a neutral density filter in the photon beam at wavelengths longer than 1943 Å.

The PCM data were brought through the interface connector and modulated an IRIG channel H subcarrier oscillator in the S band telemetry deck. This subcarrier channel, when operated for maximum frequency response, had a minimum rise time of 14 microseconds which is more than sufficient for transmission of the PCM signal with a non return to zero form and a bit width of 93 microseconds.

Voltage monitors were brought out to the interface connector and commutated by a TRI-CON commutator onto subcarrier channel 10.

The instrument operated on a 28.8 volt sealed nickel cadmium battery with a one ampere hour capacity. Instrument current was less than 0.7 amperes for less than 10 minutes during flight.

All the integrated circuit logic was of the complementary symmetry, metal oxide semiconductor (COSMOS) type.

2.2 Physical Configuration

The electronic system was made up of three sections: the pulse amplifier located on the detector assembly at the front of the instrument, six digital logic cards which were located in a card rack integral with the rear of the instrument, and a high voltage power supply and card located in the center of the housing. A dual (+13V, -13V) low voltage regulated power supply was mounted on one of the digital logic cards. All electronics was integral with the housing. The card rack was vented to the outside.

The instrument electrical interface connectors were hard mounted to the housing.

2.3 Circuit Description

A block diagram of the instrument electronics is given in Figure 2. It is similar to the electronic system in the RM 58II instrument except for the addition of the background filter circuit and deletion of the solar photometer circuits.

The pulses from the pulse amplifier, Figure 3 are fed to the photon counter card, Figure 4. The binary-coded-decimal output from the four counting stages was transferred to the two 8 bit shift registers and shifted out as word three in the three word PCM frame.

The wavelength scanner position was counted in four decade counters on the Motor Drive/ Readout card, transferred to two 8 bit shift registers and shifted out as word two in the PCM frame. A schematic is given in Figure 5. The end of scan is detected by limit switches which reverse the motor direction and at the low end also set the scan counts to 1700.

The logic circuits for driving the four position motor were included with the scanner position circuits on the Motor Drive/Readout card.

The timer card contained the PCM clock oscillator and logic circuits to generate the necessary sync pulse, shift pulses, load, inhibit, and counter reset signals. A schematic is shown in Figure 6.

The Power Supply/Test/Output card included the low voltage $\pm$ 15V converters, a test pulse generator operating at 25,000 pulses per second, load, reset, and motor trigger pulse circuits, and circuits to process the PCM data into the form required for feeding the telemetry. A schematic is given in Figure 7.

Circuits on the Filter Drive/13 card actuate a solenoid to insert a filter into the photon beam for one second when the scan is at 1900 Å and 2400 Å and is scanning towards a longer wavelength. The scan motor is stopped during the one second. The 1900 Å and 2400 Å scan readings are detected on the Motor Drive/Readout card and a trigger transferred to the filter card. Also, on this card is a circuit which counts every thirteenth motor step trigger and advances the wavelength register one Angstrom. A binary output of four bits counting 0 through 12 is picked off of this circuit and fed to the control console to be displayed along with the indicated Angstroms. A schematic is shown in Figure 8.

The Attenuator Drive card energizes a solenoid to insert the neutral density filter at wavelengths longer than 1943 Å. The scan shift register setting of 1944 is detected and sets a flip-flop when the wavelength is scanning up and resets the flip-flop when 1944 is passed on the way down. The schematic is given in Figure 9.

The logic cards are similar in appearance to those shown in the photographs in report AFGL-TR-74-0397 on RM 58.

3. GROUND SUPPORT EQUIPMENT FOR GRATING SPECTROMETER

The control console originally built for use with the RM 58II instrument was used to control the RS-61 Spectrometer. Some modification was necessary.

The most significant digit of the five digit wavelength display was blanked out and the remaining four digits displayed Angstroms directly (1700 to 3500).

A new two digit display was added to indicate the thirteen motor steps required for each Angstrom change. This indicator was driven from a new circuit card which was added to the console. It contained circuits to change the level of the 4 binary bits from the flight equipment from 13V to 5V and convert from binary to BCD coding. A schematic is shown in Figure 10.

4. ELECTRONICS FOR ELECTRON SPECTROMETER

An electronic subsystem was built to energize the Government furnished electron spectrometer detector.

The electronics generated 64 different voltages

which were applied in sequence to the detector plates. The electrons collected at each voltage (energy level) were multiplied in a channel electron multiplier in the detector assembly and the current bursts (each burst representing one electron) were counted in a 4 decade decimal counter (16 bits).

The 16 bit electron count, along with six binary bits representing the 64 detector voltage levels at which the electrons were collected, and a 16 bit sync word comprised the PCM frame of 48 bits. A timing diagram is given in Figure 11. The frame rate was 50 per second. Thus, the electron collection time for each voltage step was 20 milliseconds (actually 15 microseconds less than 20 milliseconds or 19.985 milliseconds).

The detector voltages range from less than a volt to more than 64 volts and the ratio of successive voltages was held to better than 1/2 of one percent of 1.06. A table of voltages is given in Table 1.

A high voltage power supply and filter card for the electron multiplier was mounted adjacent to the multiplier. The output pulses from the multiplier were amplified in a pulse amplifier and fed to the counter and logic boards which were located in a box mounted on the side of the RS-61 Spectrometer opposite the bolt circle.

The box contained five printed circuit cards and two low voltage power supplies. The five cards were: a timer card to generate the PCM frame logic; a test/output card which contained a test generator and also circuits to combine the electron count, step number, and sync word to make the complete PCM output waveform; a counter card; a step generator card; and step drive card. Schematics of the cards are given in Figures 12 through 15.

The pulse amplifier is similar to that used in RS-61. A block diagram of the electronic system is given in Figure 16.

A G.S.E. console was used to operate the electron spectrometer system during acceptance and environmental test, calibration integration and in the field prior to launch. The console was also used to decode the electron count and voltage step from the flight magnetic tape for quick look data reduction immediately after the rocket flight.

This console was designed and built by TRI-CON ASSOCIATES, INC., on a subcontract from Comstock & Wescott contract (F19628-73-C-0253.)

The PCM data frame was telemetered on IRIG channels F and 17. The high voltage monitor was on channel 16. In addition the high voltage monitor was commutated by the TRI-CON commutator.

5. TESTS

The RS-61 instrument was delivered to AFGL on 15 September 1975. It was checked per the Test and Acceptance Plan dated 9 September 1975.

The Electron Spectrometer electronics was delivered to AFGL on 30 March 1976. It was checked at AFGL per R&D Test and Acceptance Plan dated 5 April 1976, and mounted on the RS-61 housing and prepared for a vibration test. On 16 April it was vibrated along with the RS-61 instrument at the AFGL vibration facilities. No failures occurred.

6. FIELD SERVICES

The complete instrument was integrated with the pointing control at Ball Brothers Research Corporation, Boulder, Colorado during the week of 26 April 1976. The electronics performed correctly during all integration phases. R. Hills spent the entire week at Boulder.

Pre-launch procedures were carried out the week of 10 May 1976. At WSMR the instrument was launched aboard an Aerobee 150 rocket from B Tower at LC-35 at 1100 hours MDT. Data was obtained from both instruments and the entire payload was recovered. R. Hills was at WSMR 10 May 1976 through 18 May 1976.

A launch report was filed by Comstock & Wescott on Contract F19628-74-C-0002.

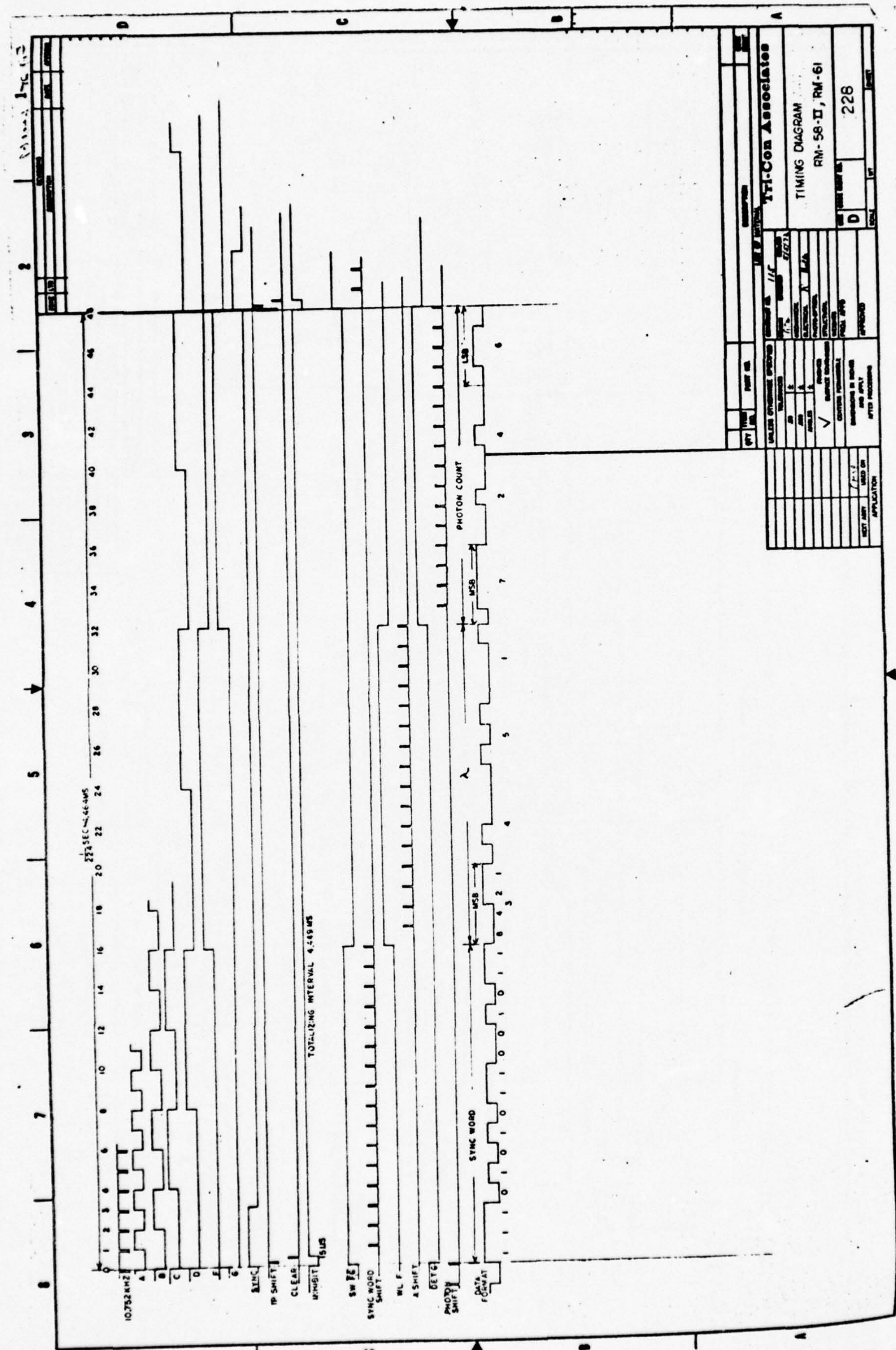
TABLE I

ELECTRON SPECTROMETER #2 LADDER VOLTAGES

STEP	V+	V-
0	.006	.002
1	.157	.153
2	.320	.316
3	.491	.486
4	.670	.665
5	.862	.857
6	1.068	1.062
7	1.285	1.280
8	1.457	1.451
9	1.546	1.542
10	1.641	1.636
11	1.741	1.736
12	1.848	1.843
13	1.960	1.955
14	2.078	2.073
15	2.204	2.199
16	2.351	2.344
17	2.492	2.486
18	2.645	2.638
19	2.805	2.799
20	2.974	2.966
21	3.154	3.146
22	3.346	3.339
23	3.551	3.543
24	3.764	3.755
25	3.993	3.983
26	4.234	4.224
27	4.486	4.476
28	4.758	4.747
29	5.042	5.031
30	5.341	5.329
31	5.661	5.649
32	6.084	6.068

TABLE I cont'd

STEP	V+	V-
33	6.445	6.430
34	6.837	6.820
35	7.245	7.339
36	7.675	7.657
37	8.135	8.118
38	8.629	8.610
39	9.149	9.132
40	9.680	9.690
41	10.27	10.28
42	10.88	10.89
43	11.53	11.54
44	12.22	12.23
45	12.95	12.96
46	13.71	13.72
47	14.53	14.53
48	15.76	15.76
49	16.70	16.69
50	17.71	17.70
51	18.76	18.75
52	19.87	19.86
53	21.11	21.07
54	22.39	22.34
55	23.73	23.69
56	25.14	25.09
57	26.65	26.59
58	28.24	28.18
59	29.90	29.84
60	31.69	31.62
61	33.56	33.50
62	35.53	35.45
63	37.63	37.56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RM-58-II, RM-61
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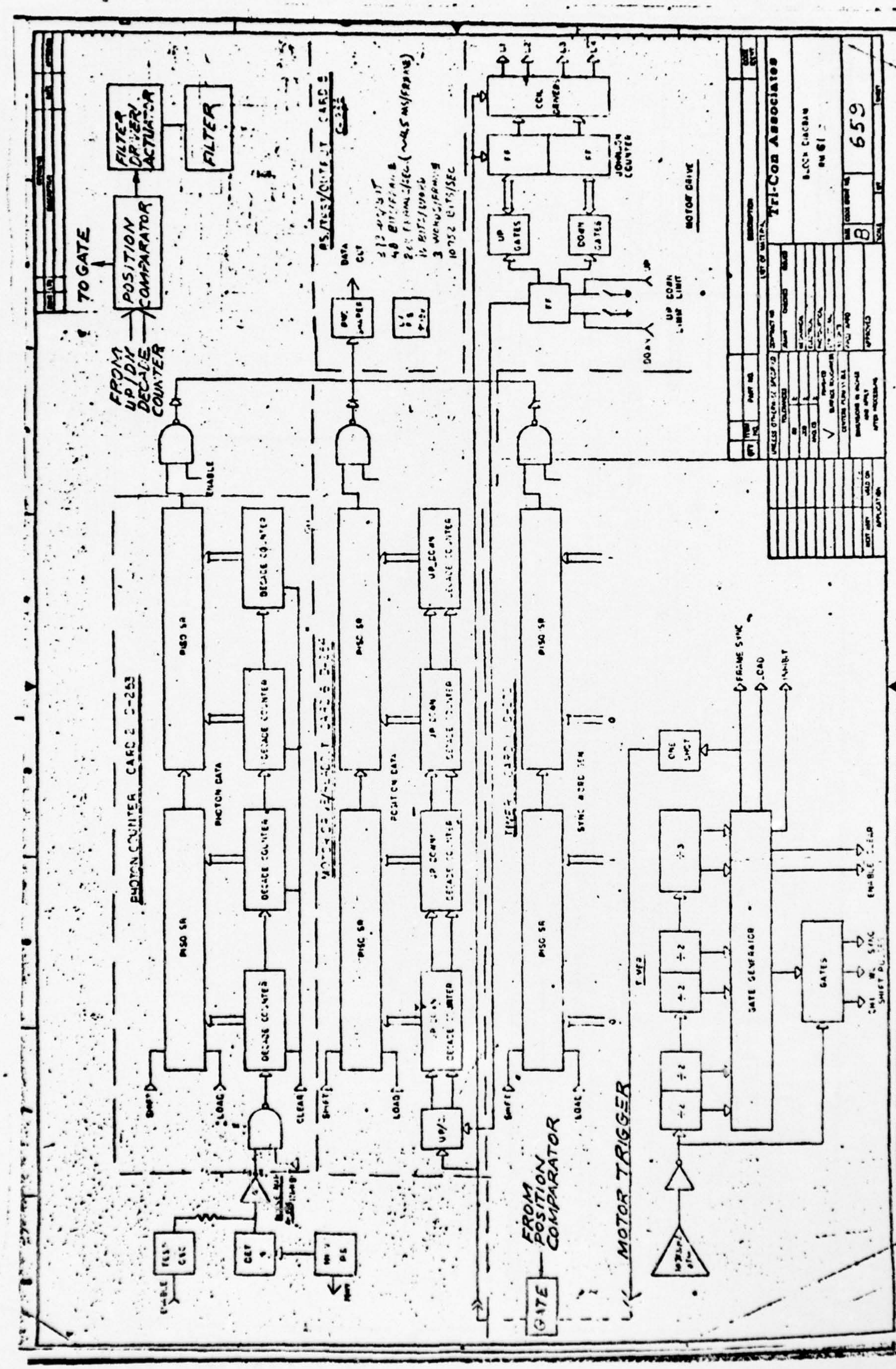
CLEAR
INHIBIT
SYNC WORD SHIFT
DET G
DATA FORMAT
TOTALIZING INTERVAL 4.449MS
SYNC WORD
PHOTON COUNT
MSB
LSB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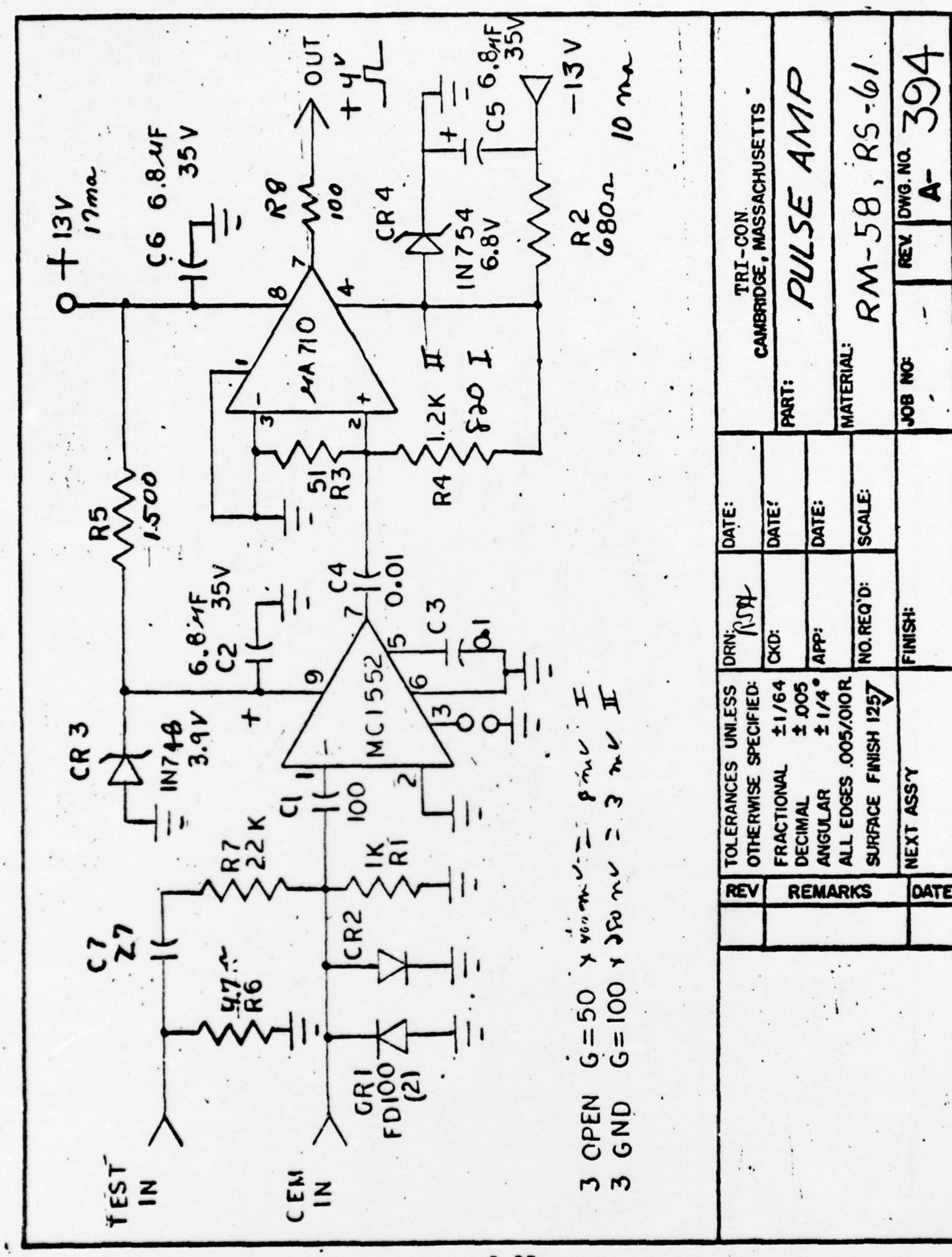
POSITION COMPARATOR
FILTER DRIVER/ACTUATOR
FILTER
FROM UP/DN DECADE COUNTER
PHOTON COUNTER
PISO SR
DECADE COUNTER
PHOTON DATA
POSITION DATA
MOTOR DRIVE
FROM POSITION COMPARATOR
MOTOR TRIGGER
GATE
GATE GENERATOR
GATES
FRAME SYNC
LOAD
INHIBIT
JOHNSON COUNTER
UP GATES
DOWN GATES
Tri-Con Associates
659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CAMBRIDGE, MASSACHUSETTS
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MATERIAL: RM-58, RS-61
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DECIMAL ±.005
ANGULAR ±1/4°
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REMARKS
DATE
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CKD:
APP:
NO. REQ'D:
FINISH:
SCALE:
JOB NO:
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CEM IN
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μA710
+13V
17ma
-13V
10ma
OUT
+4V
R5 1500
R8 100
R2 680Ω
R4 1.2K I 820 II
R3 51
R7 22K
R1 1K
R6 47Ω
C7 27
C1 100
C4 0.01
C3 .01
C2 6.8μF 35V
C5 6.8μF 35V
C6 6.8μF 35V
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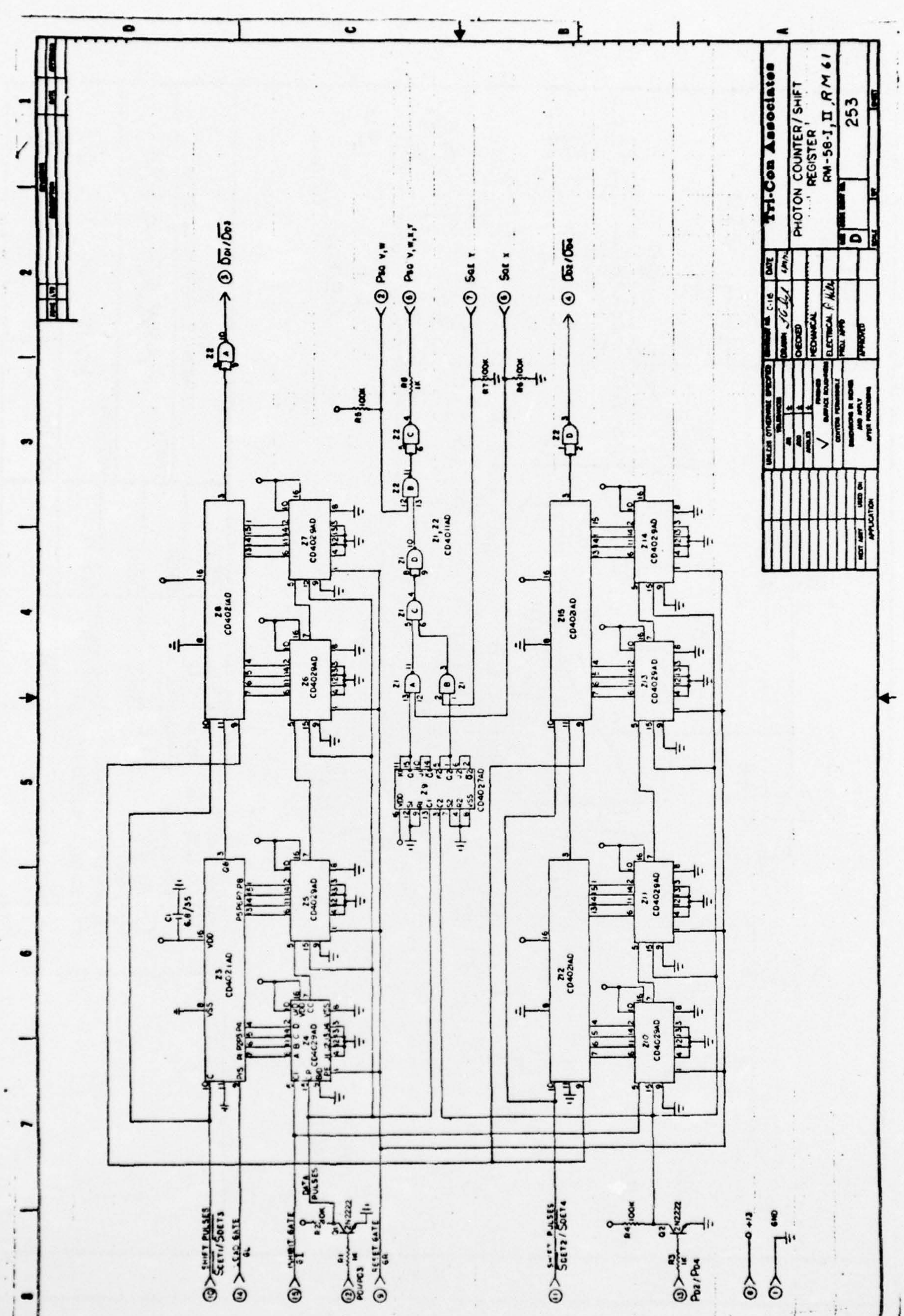
CR4 1N754 6.8V
CR2
GR1 FD100 (2)
3 OPEN G=50
3 GND G=100

Figure 2.16


Tri-Con Associates
PHOTON COUNTER/SHIFT REGISTER
RM-58-I, II, RM 61
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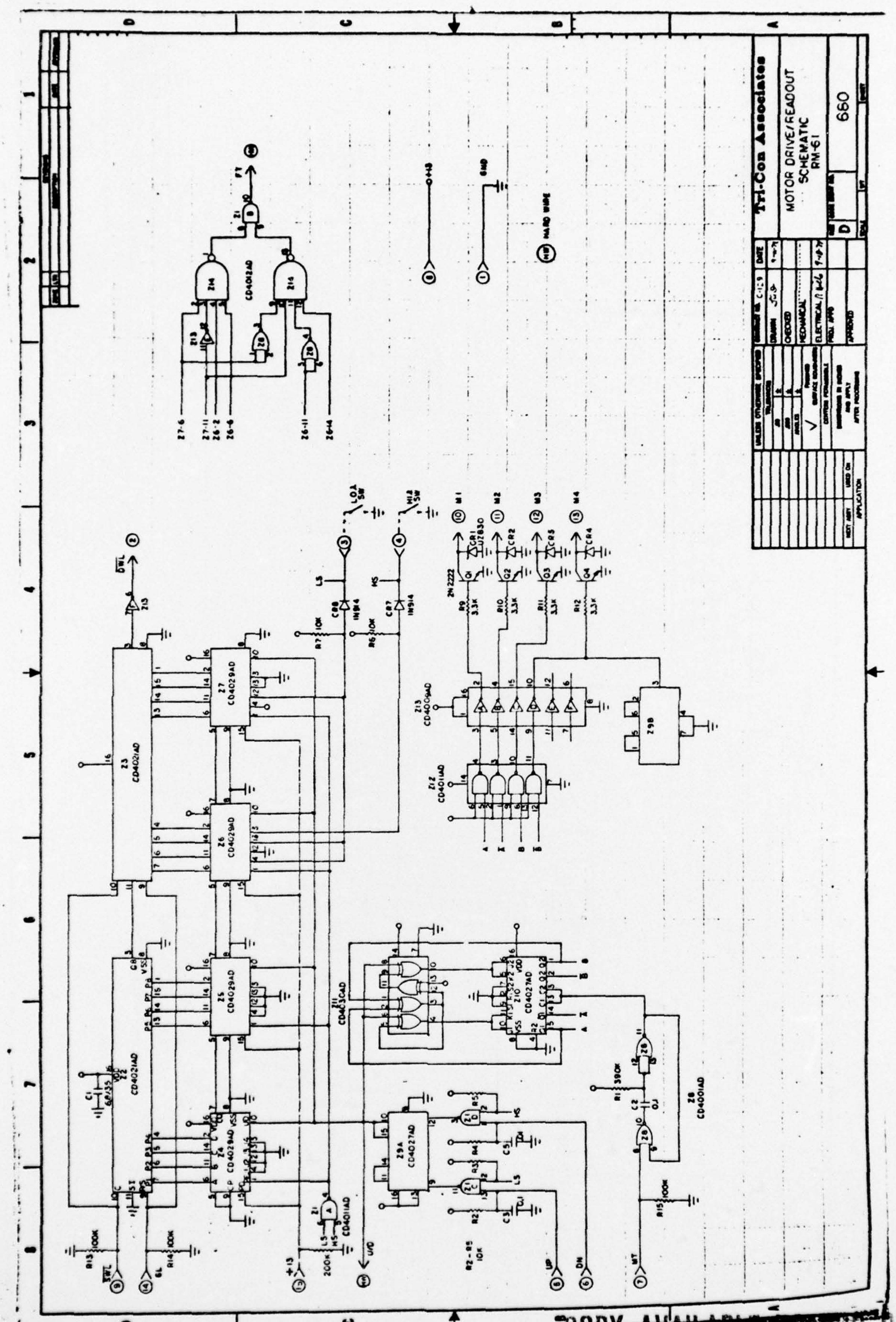
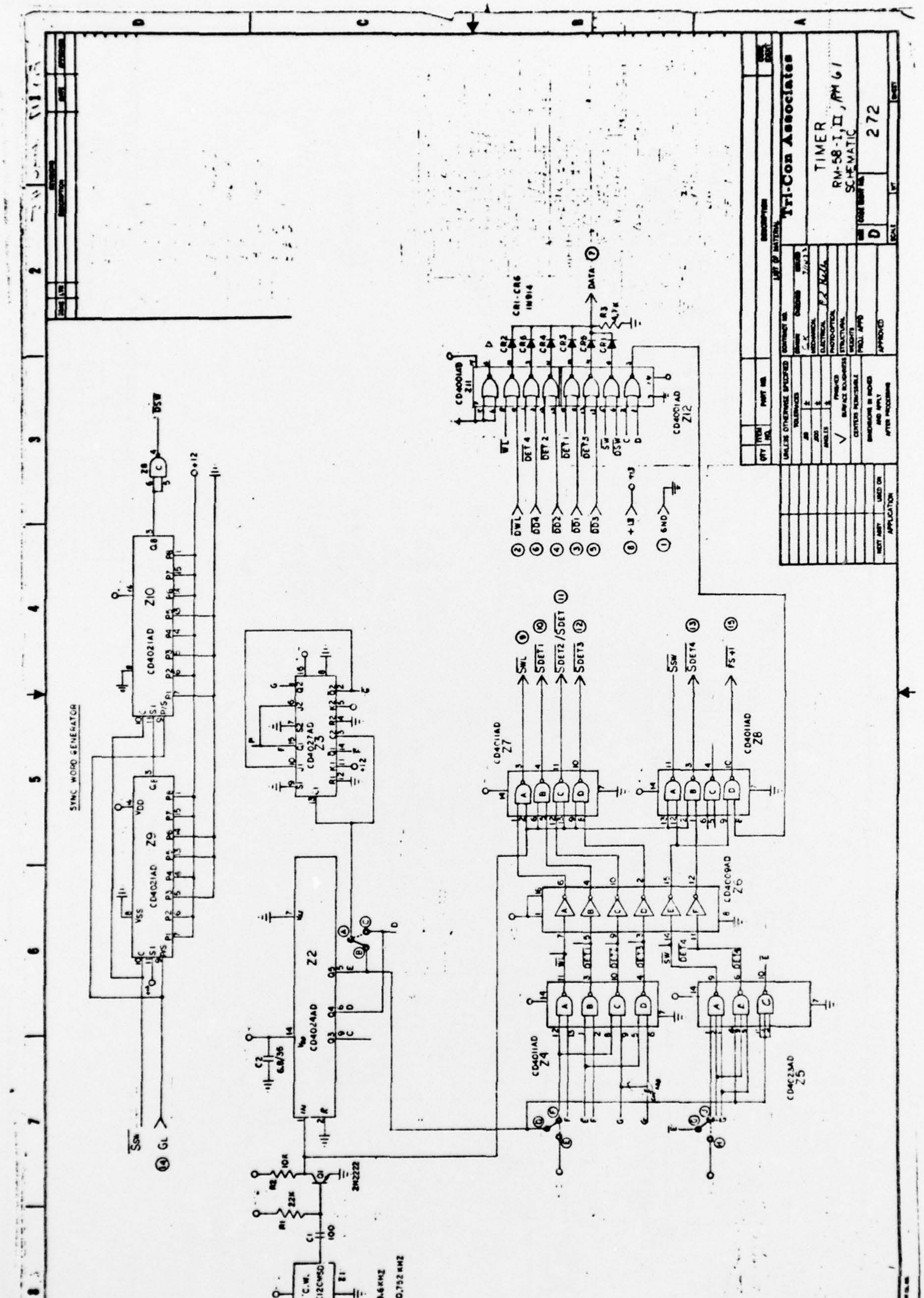
CD4021AD
CD4011AD
CD4027AD
SHIFT PULSES
DATA PULSES
2N2222



Tri-Con Associates
MOTOR DRIVE/READOUT
SCHEMATIC
RM-61
660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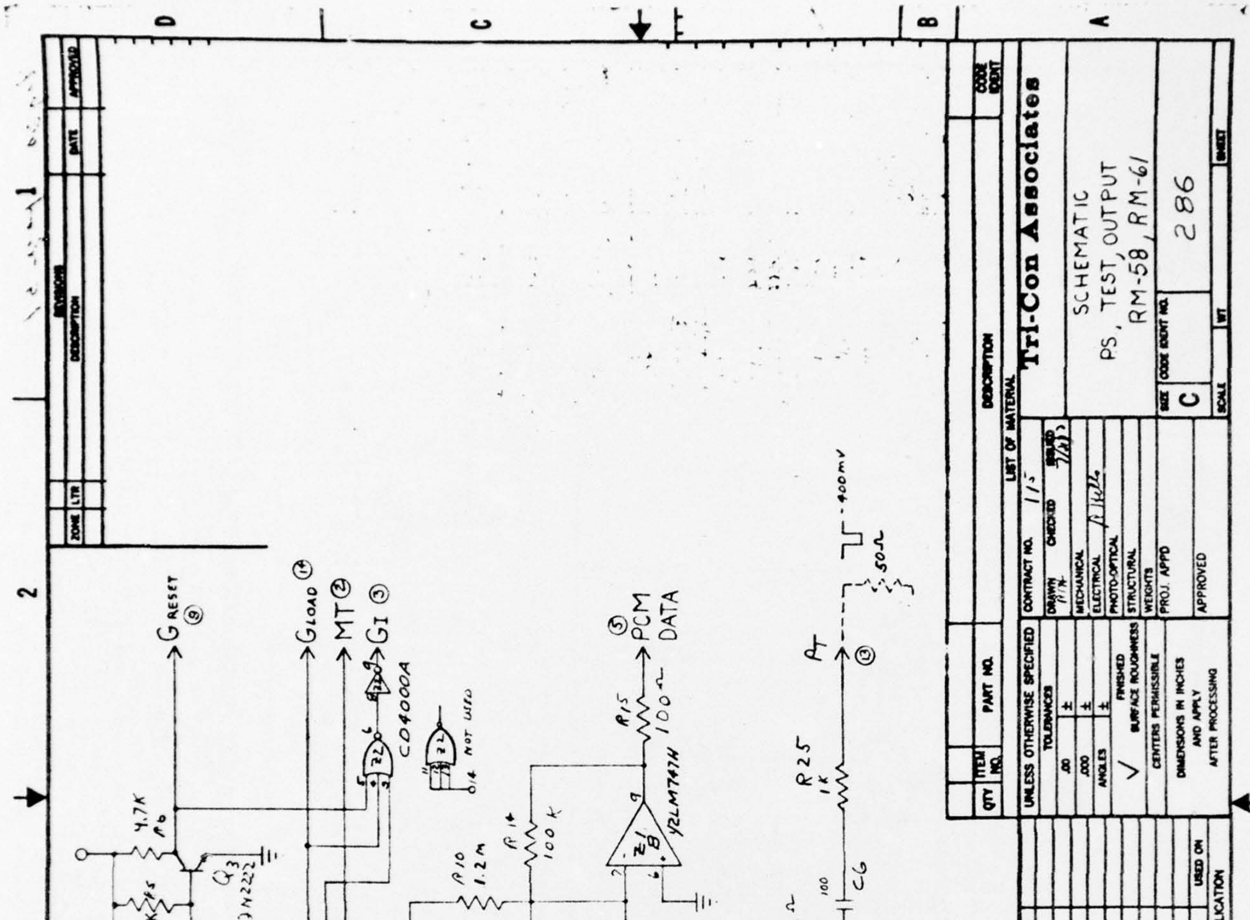
RM-58-I, II, /RM 61
SCHEMATIC
272
SYNC WORD GENERATOR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SCHEMATIC
PS, TEST, OUTPUT
RM-58, RM-61
286
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NEXT ASSY
USED ON
APPLICATION
REVISIONS
G RESET
G LOAD
MT
GI
PCM DATA
CD4000A
CD4011A
1/2 LM747H
TECNETICS 9567-121 3W I 15V
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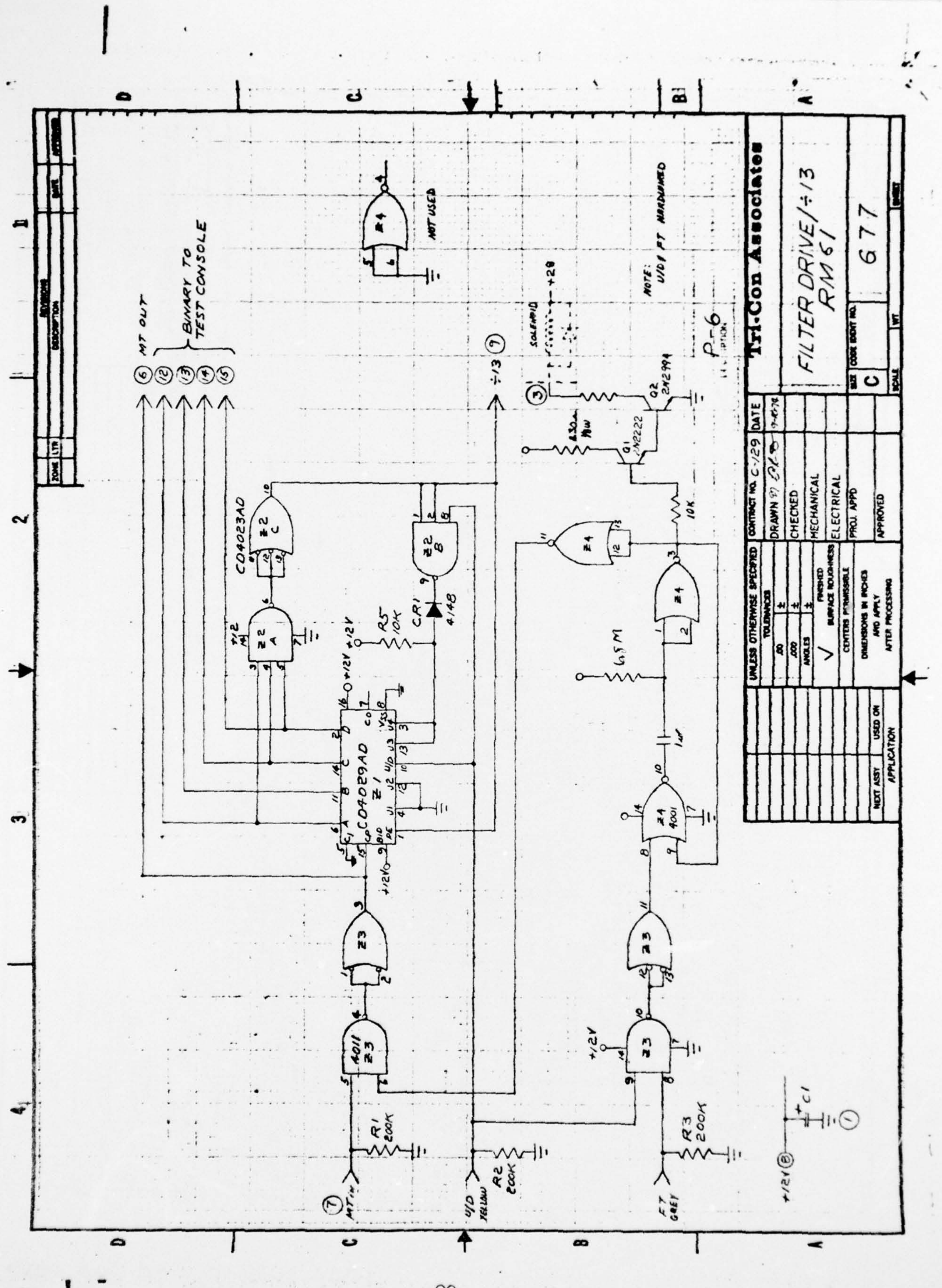
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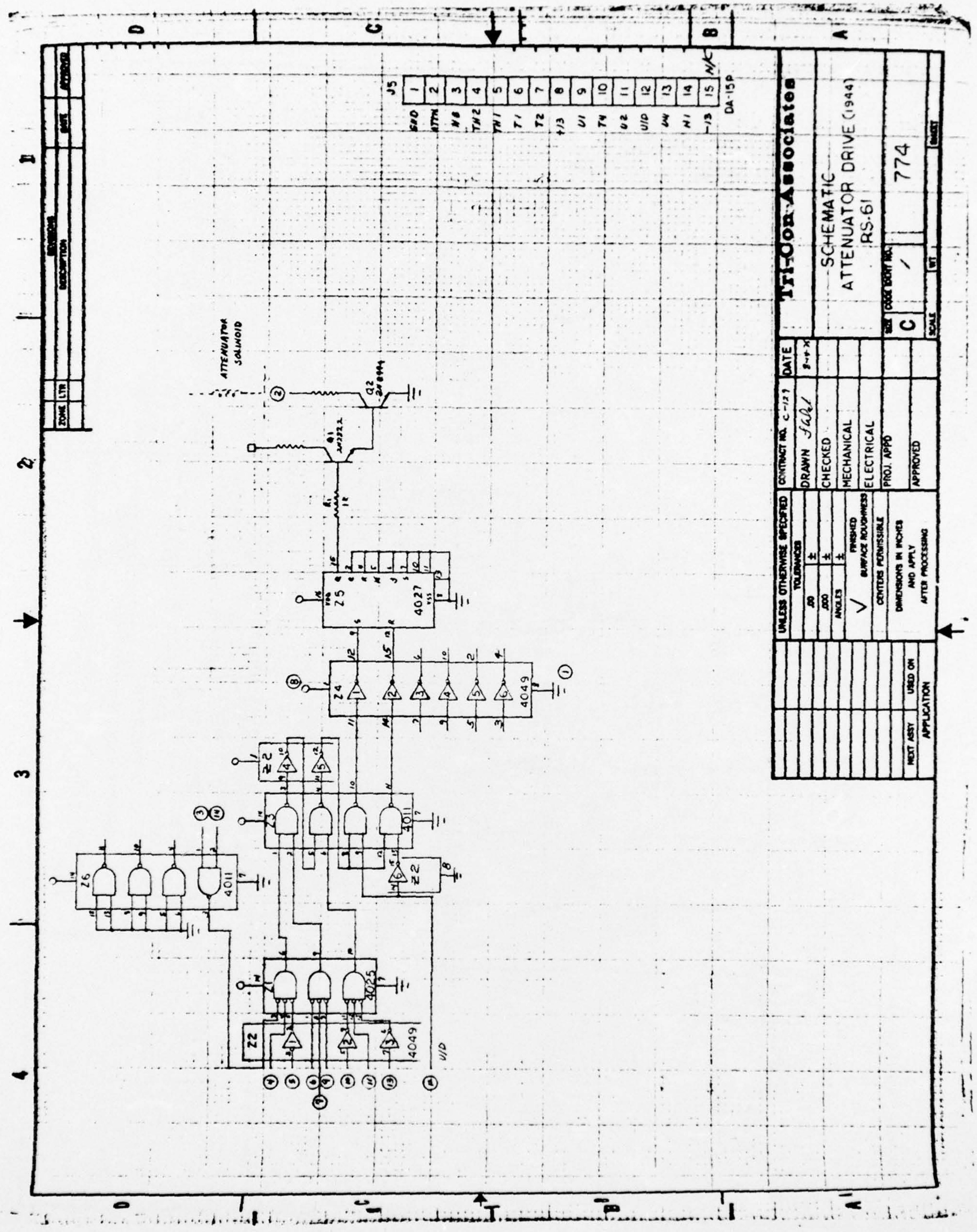

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RS-61
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ATTENUATOR SOLENOID
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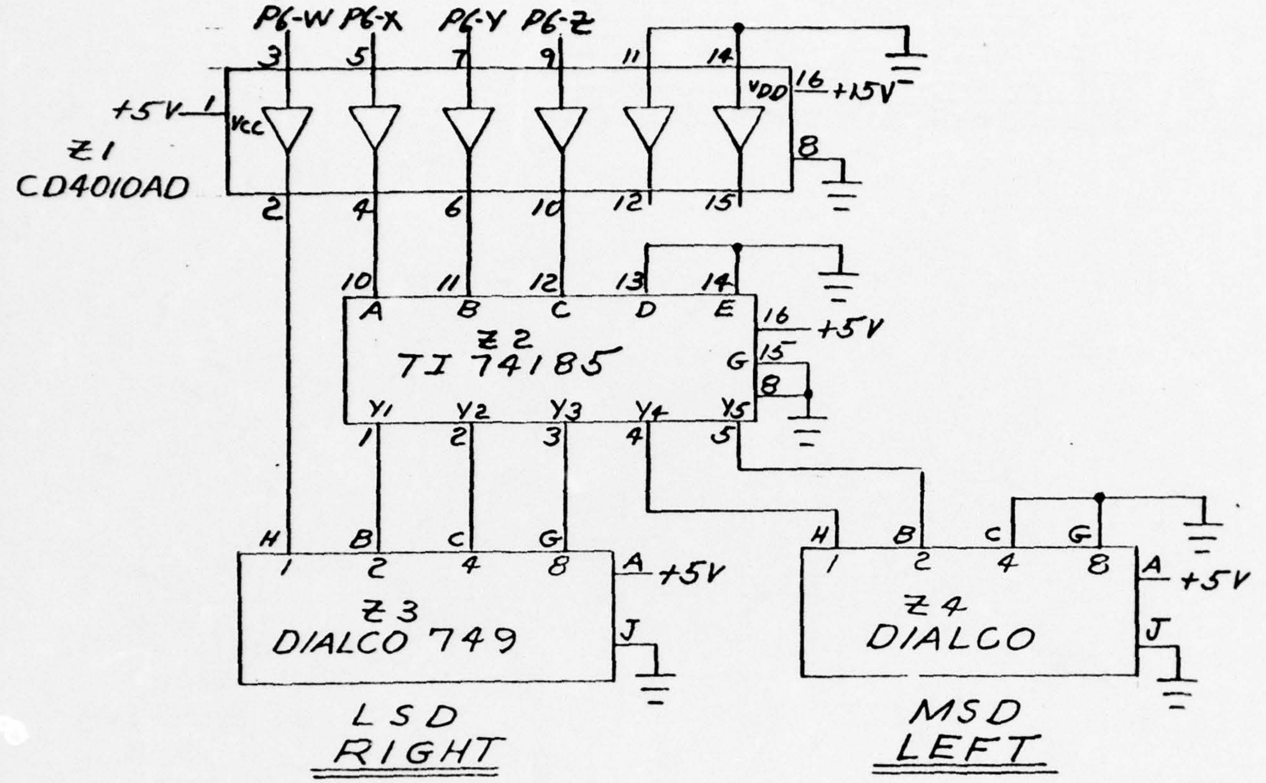
4049
4011
4025
DA-15P



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TRI-CON ASSOCIATES, INC.
CAMBRIDGE, MASSACHUSETTS

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MATERIAL:

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C-129		A-682

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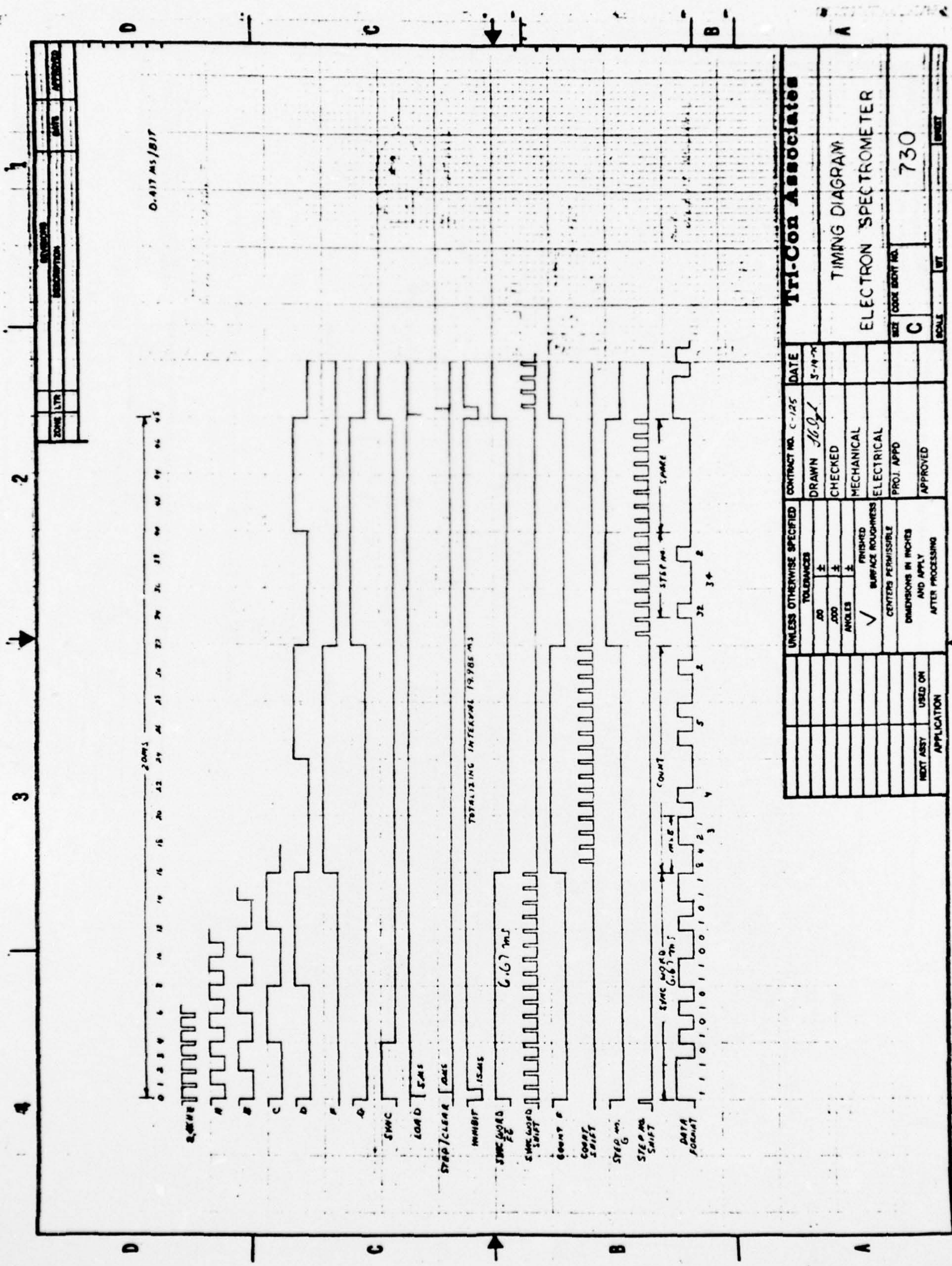
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CONTRACT NO. C-125
DRAWN
DATE
CHECKED
MECHANICAL
ELECTRICAL
PROJ. APPD
APPROVED
UNLESS OTHERWISE SPECIFIED
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FINISHED
SURFACE ROUGHNESS
CENTERS PERMISSIBLE
DIMENSIONS IN INCHES
AND APPLY
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NEXT ASSY
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COUNT
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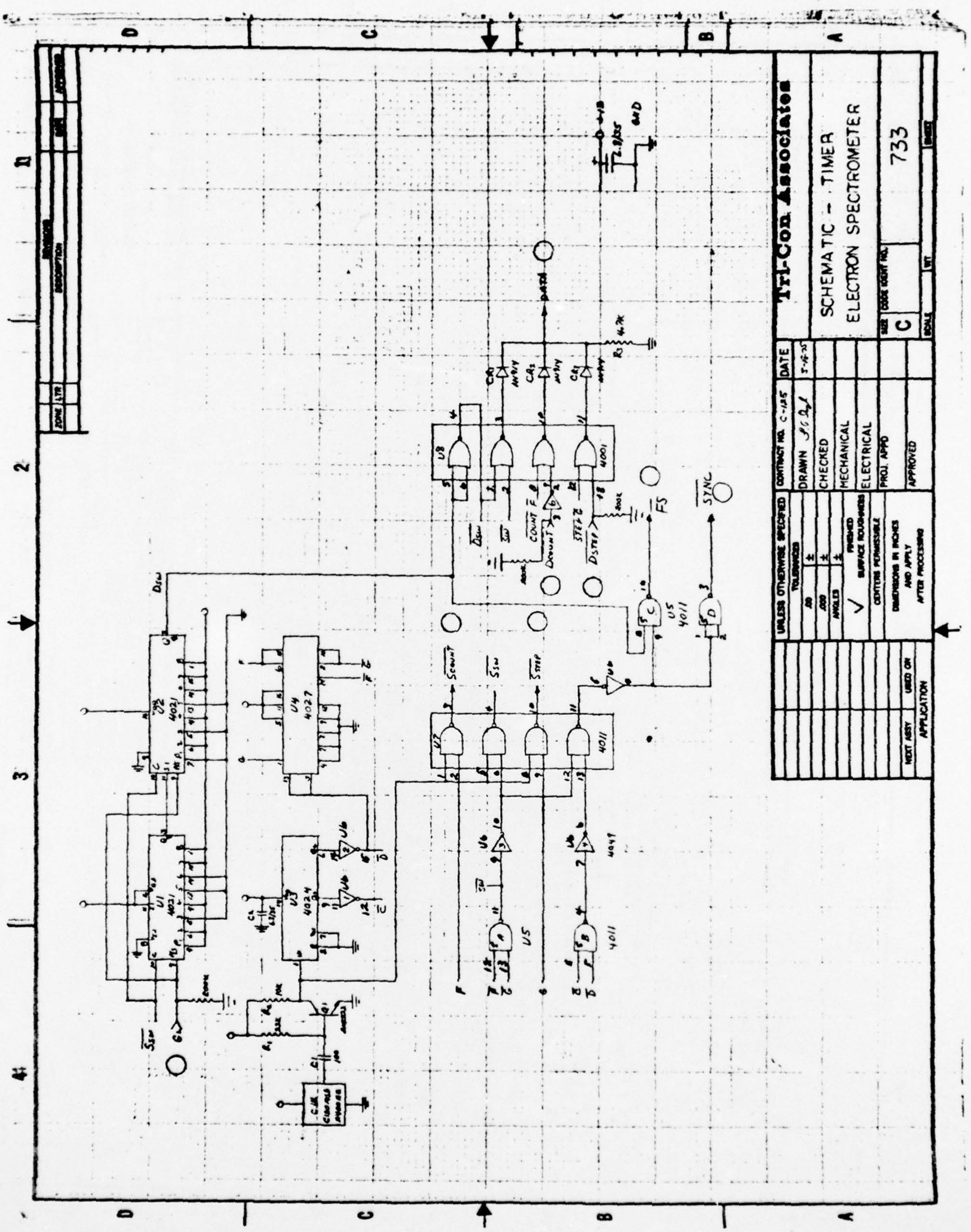
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SCHEMATIC - TIMER
ELECTRON SPECTROMETER
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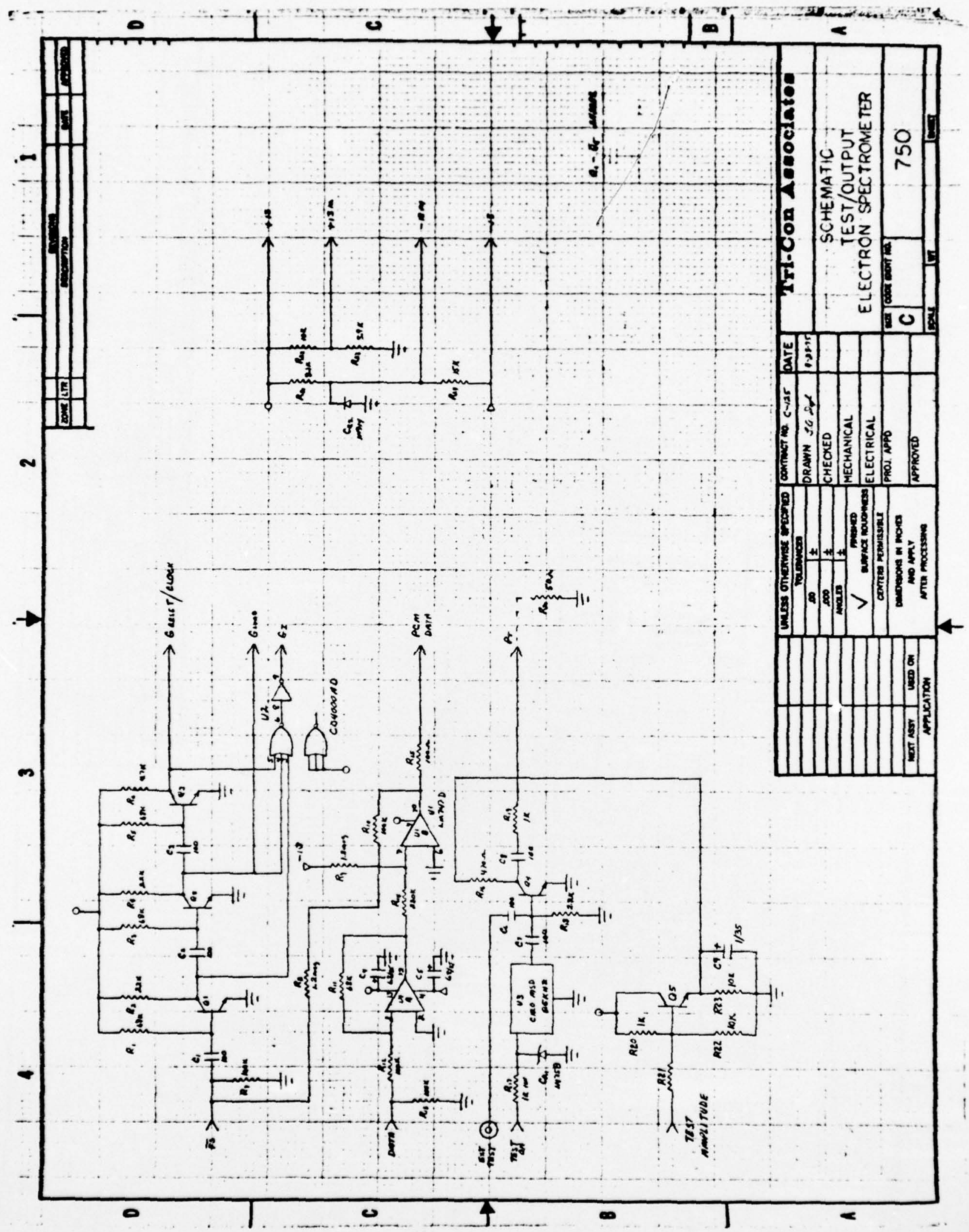
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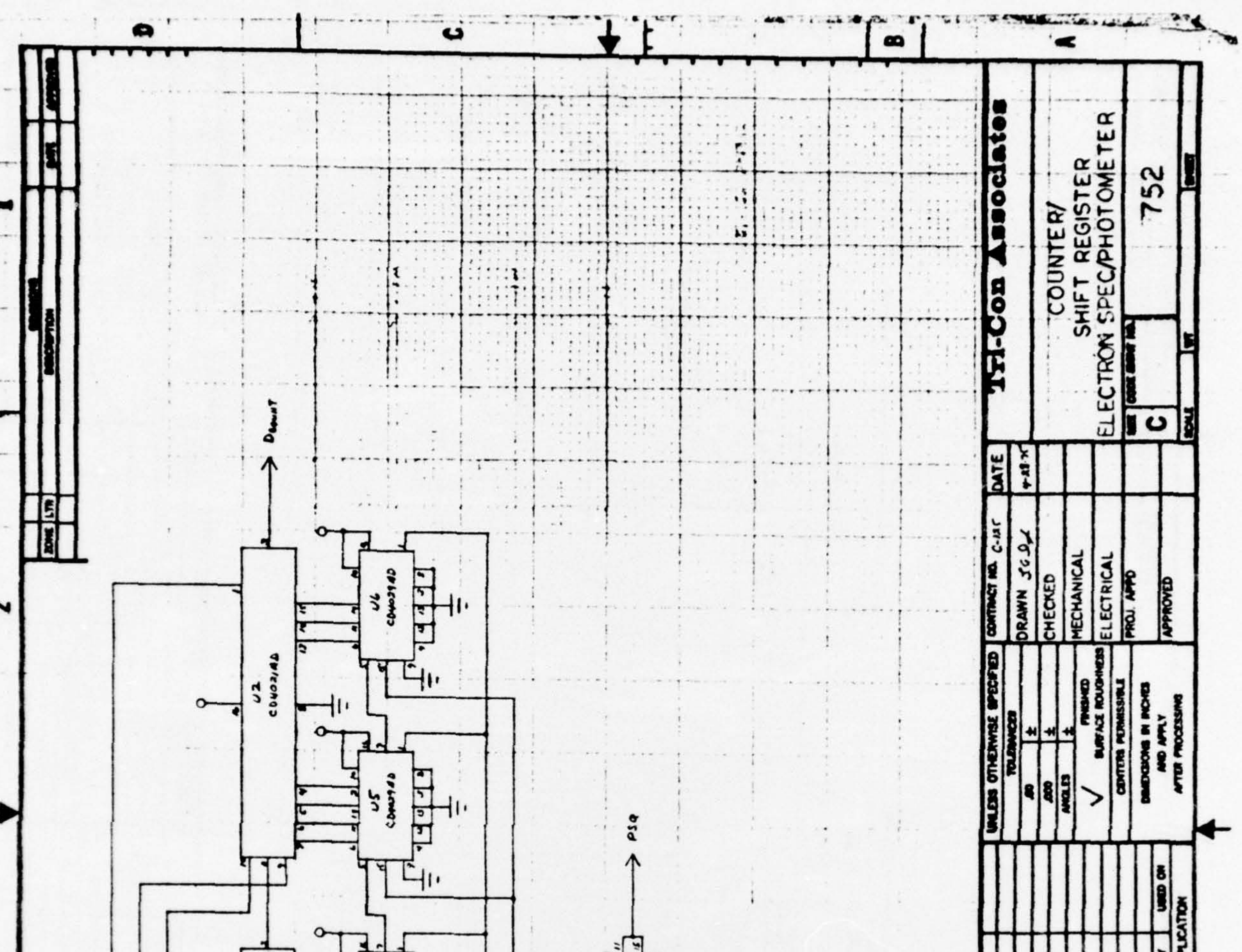

Tri-Con Associates
COUNTER/
SHIFT REGISTER
ELECTRON SPEC/PHOTOMETER
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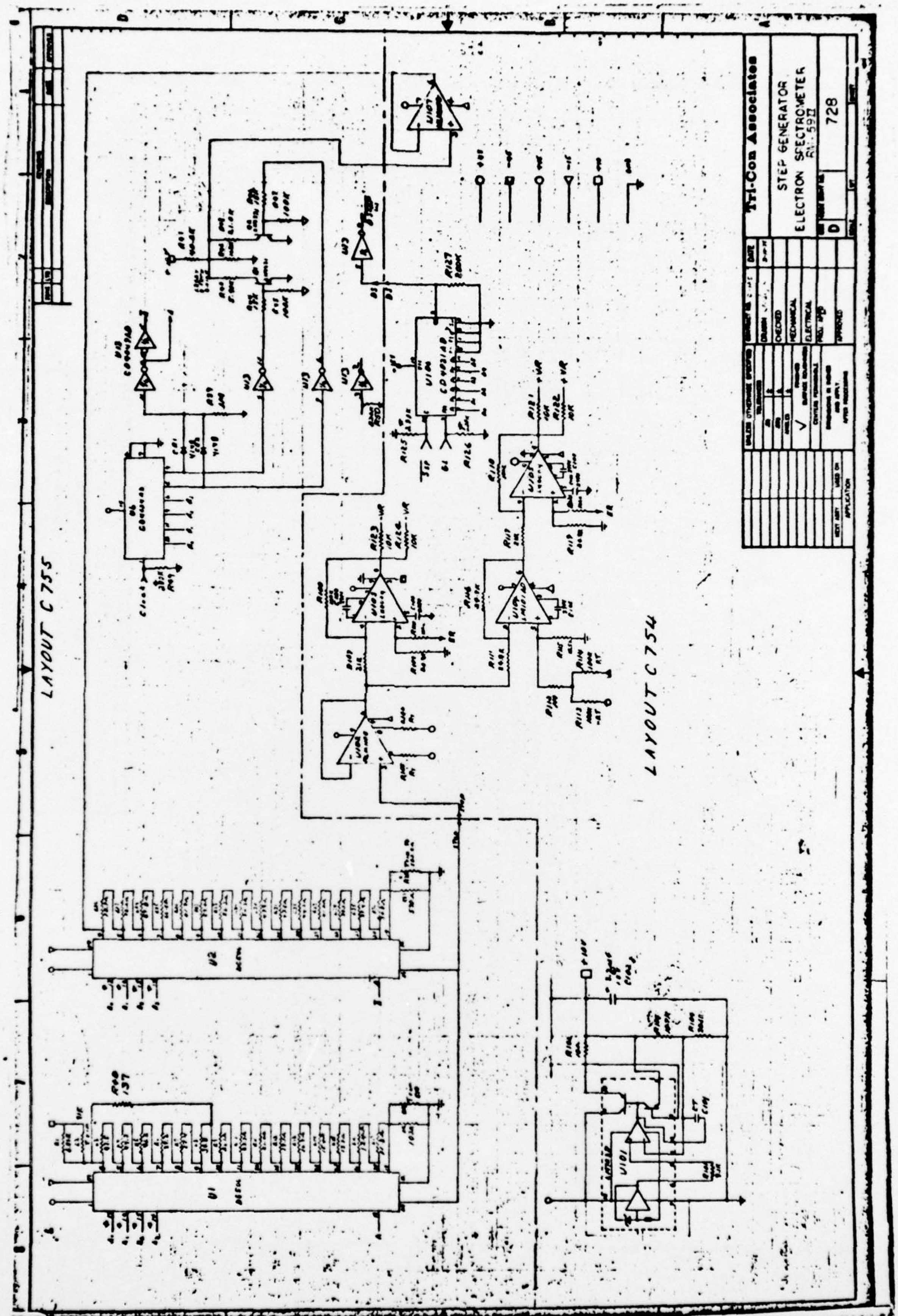
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ELECTRON SPECTROMETER
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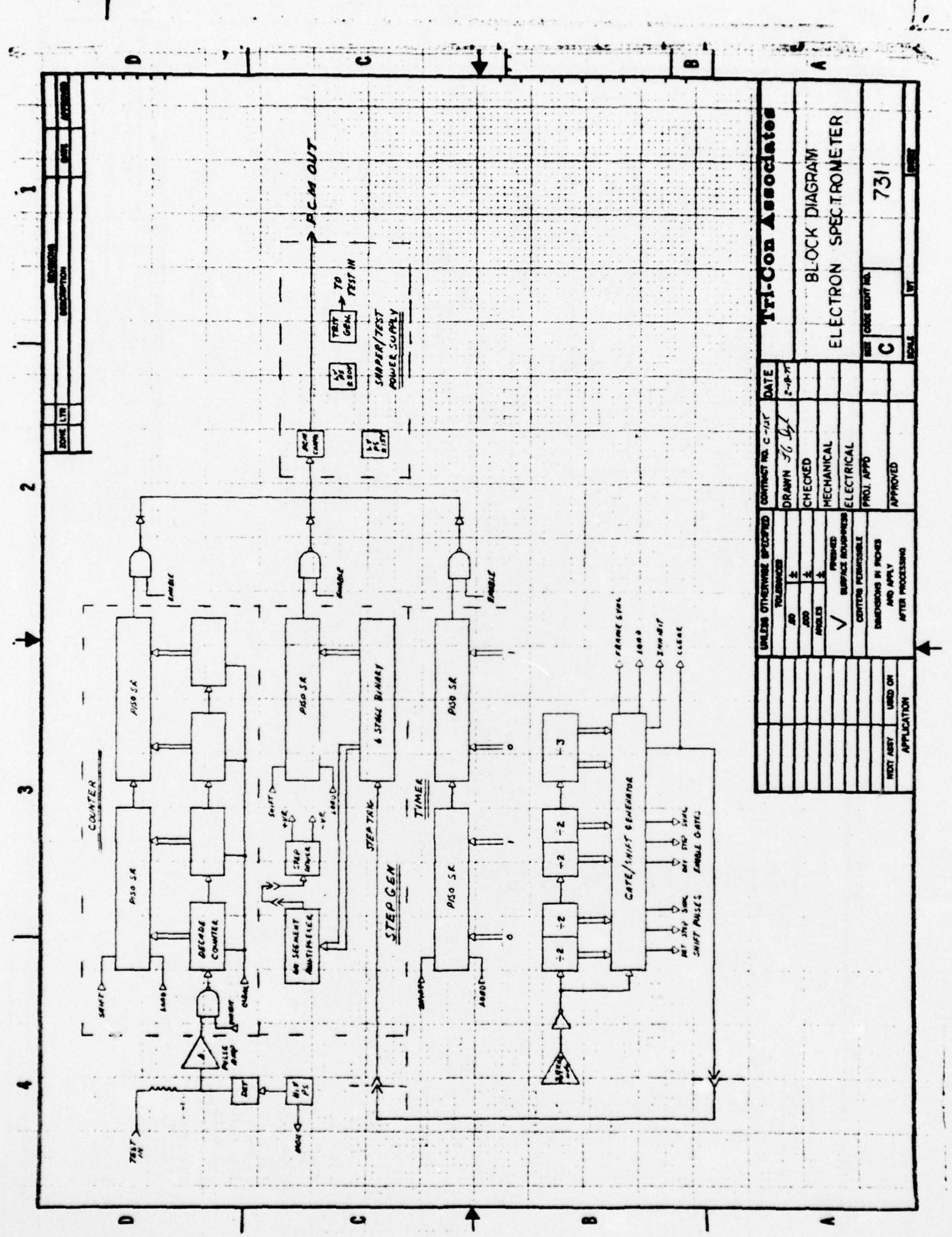
LAYOUT C 755
LAYOUT C 754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PISO SR
DECADE COUNTER
STEP DRIVER
6 STAGE BINARY
STEP TRIG
STEP GEN
TIMER
GATE/SHIFT GENERATOR
PCM OUT
TEST GEN
TO TEST IN
SHAPER/TEST POWER SUPPLY
SHIFT PULSES
FRAME SYNC
INHIBIT
CLEAR
ENABLE
TEST IN